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Abstract

Fuel Cycle Physics and Economics for Heavy Water Reactors

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Sweden is engaged in the development of heavy water moderated reactors of the pressure vessel type using slightly enriched uranium for normal operation. The present reactor programme, based on the prospective energy needs over the next two decades and the most economical way of developing the overall power system, is briefly outlined.

From the aspect of fuel cycles two important items influence the choice of a particular reactor type, namely long range fuel utilization and fuel cycle economics. The prospective consumption of natural uranium in Sweden is compared for different reactor types, including the heavy water moderated Marviken reactor type, the light water moderated advanced converter reactor and the fast breeder reactor. Fuel cycle costs are compared with special regard to the effects of feed cost, fabrication and reprocessing costs, uranium and plutonium credit, and burnup.

The characteristics of current Swedish fuel cycle policy are discussed. This involves consideration of the use of natural or enriched fuel, the need for chemical reprocessing of spent fuel, and the possibility of plutonium recycling. Presently adopted fuel cycles for the 200 Mw elect. Marviken reactor, which has entered the construction phase, and for the 350 Mw elect. PHWR conceptual design will be discussed. The Marviken reactor is being designed for on-power refuelling, whereas PHWR uses refuelling at shut-down. Both reactors use fuel management as a means of reactivity

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control and power shaping. The implications of these features for reactor operation and fuel cycle costs are evaluated. The operational problem of approach to fuel cycle equilibrium is indicated.

It is shown that there is at the present time an economic incentive to use slightly enriched fuel in the heavy water reactors under consideration, whereas no chemical reprocessing of spent fuel is required. As a possible development the use of plutonium recycle is considered. The value of plutonium and the possibility of self-sustained recycling with natural uranium feed are discussed. Different refuelling schemes, plutonium feed compositions and cost assumptions are included. Different heavy water reactor types are compared, including cooling with pressurized water, saturated steam and internally superheated steam. Optimization of reactor parameters for the use of plutonium is considered.